

General Certificate of Secondary Education

A514/03

Design and Technology:

Innovator Suite

Control Systems: Mechanisms

Unit A514: Technical aspects of designing and making

Specimen Paper

Time: 1 hour 15 minutes

Candidates answer on the question paper.

Additional materials:

Candidate
Forename

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Candidate
Surname

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Centre
Number

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Candidate
Number

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INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each answer carefully and make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do not write in the bar codes.
- Do not write outside the box bordering each page.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is 60.

FOR EXAMINER'S USE

1	
2	
3	
4	
5	
TOTAL	

This document consists of **14** printed pages and **2** blank pages.

[Turn over

Section A

Answer **all** questions.

- 1 Fig. 1 shows a range of hand tools which include the use of mechanisms.



Fig. 1

- (a) (i) State the type of gear used at point **X** in the hand drill.

[1]

- (ii) Calculate the gear ratio of the drill mechanism.

Use the formula gear ratio = driven / driver.

..... [2]

- (iii) If the handle of the hand drill is rotated at 50 RPM calculate the rotation speed of the drill bit.

..... [2]

- (b) The brace shown in Fig. 2 uses a crank to apply turning effort to the drill bit.
- (i) Using the information shown in Fig. 2 give the class of lever that is used in the brace.

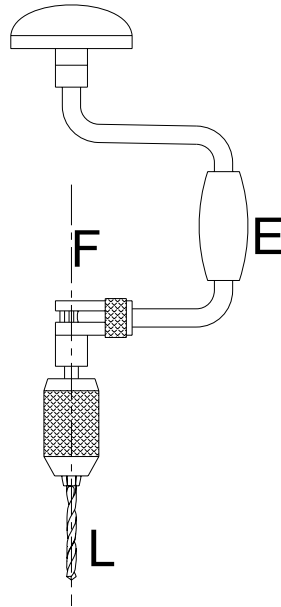


Fig. 2

- [1]
- (ii) Give **one** method of increasing the torque of the brace.
- [1]
- (c) A close up view of the chuck end of the brace is shown in Fig. 3.



Fig. 3

The mechanism at point Y will allow the chuck to rotate in one direction only.

This direction can be changed using the rotating collar.

- (i) State the name of the mechanism.
- [1]

(ii) Describe how the mechanism operates.

.....
 [2]

(d) Two G cramps are shown in Fig. 4 with enlarged views of the thread and pressure pad of each.

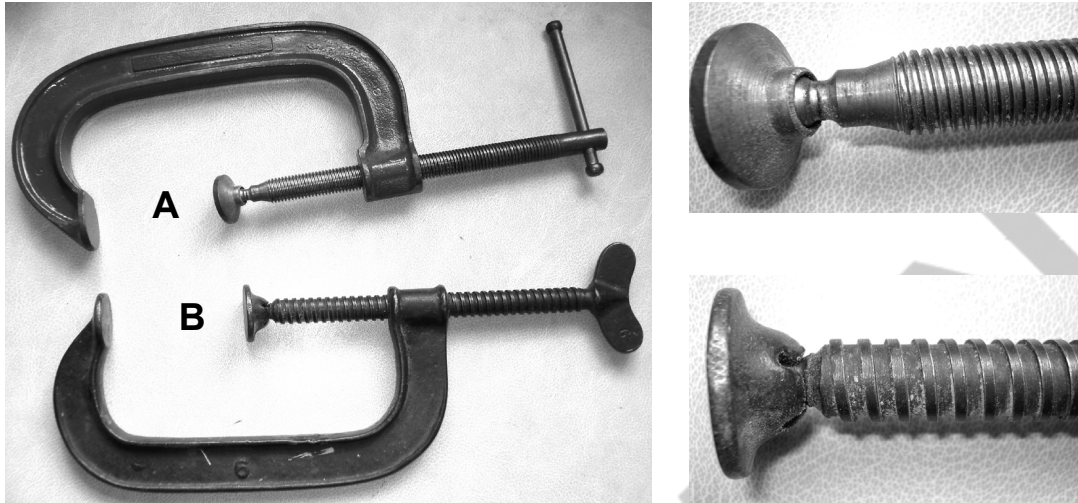


Fig. 4

Explain why cramp **A** is capable of applying greater force than cramp **B** when the same effort is applied to each.

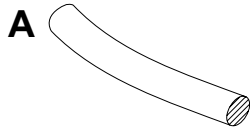
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 [2]

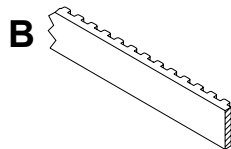
[Total: 12]

2 (a) Mechanisms often include the drive systems shown in Fig. 5.

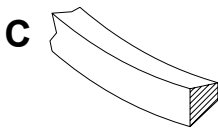
(i) Name each drive system.



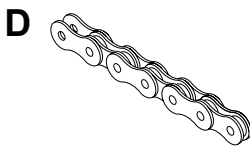
A [1]



B [1]



C [1]



D [1]

Fig. 5

(ii) Give **one** benefit of drive system **B** when compared to drive system **A**.

.....
 [1]

(b) Fig. 6 shows drive system **C** being used to take the drive from a motor to a machine shaft.

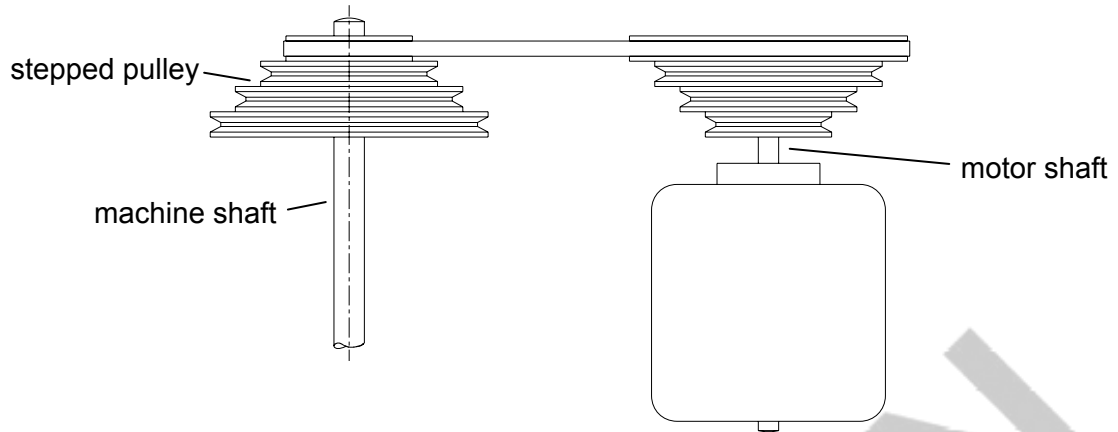


Fig. 6

- (i) Describe the speed of the machine shaft when compared to the motor shaft with the belt in the position shown.

..... [1]

- (ii) Use notes and sketches to show how the stepped pulley in Fig. 6 could be fixed to the machine shaft.

The stepped pulley should be removable to allow for maintenance.

[3]

(c) Two types of bearing are shown in Fig. 7.

Either type could be used on a machine shaft.

(i) Explain why the ball bearing would normally be chosen in preference to the plain

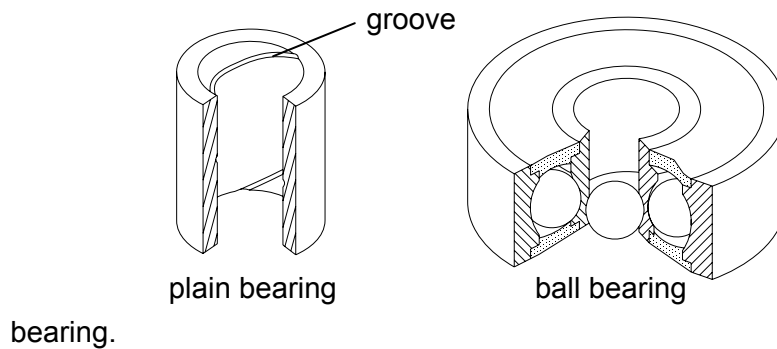


Fig. 7

.....

 [2]

(ii) State the purpose of the groove shown on the plain bearing.

.....
 [1]

[Total 12]

3 Fig. 8 shows the drive of a mountain bike.

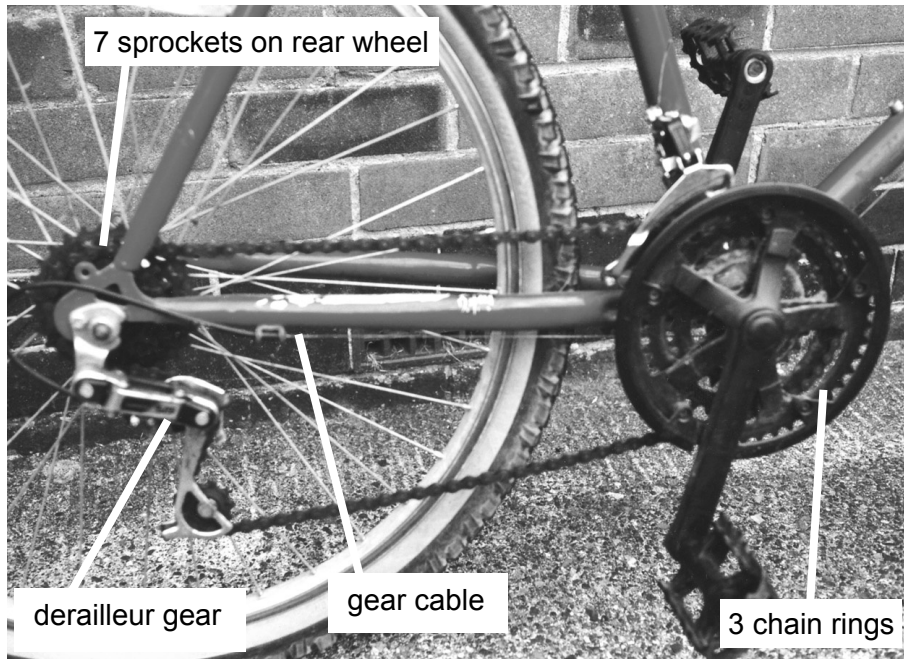


Fig. 8

(a) (i) State the number of gears that can be selected on the mountain bike.

..... [1]

(ii) The circumference of the wheel is 2075mm.

Calculate the distance travelled by the bike for **one** complete revolution of the crank if a 49t chain ring and a 16t rear gear are in use.

..... [3]

(iii) Give **two** functions of the derailleur gear mechanism.

1 [1]

2 [1]

(b) The gear cable is made from twisted steel wire.

Give **two** properties that will be required from the cable.

1 [1]

2 [1]

(c) A brake lever from the bike is shown in Fig. 9.

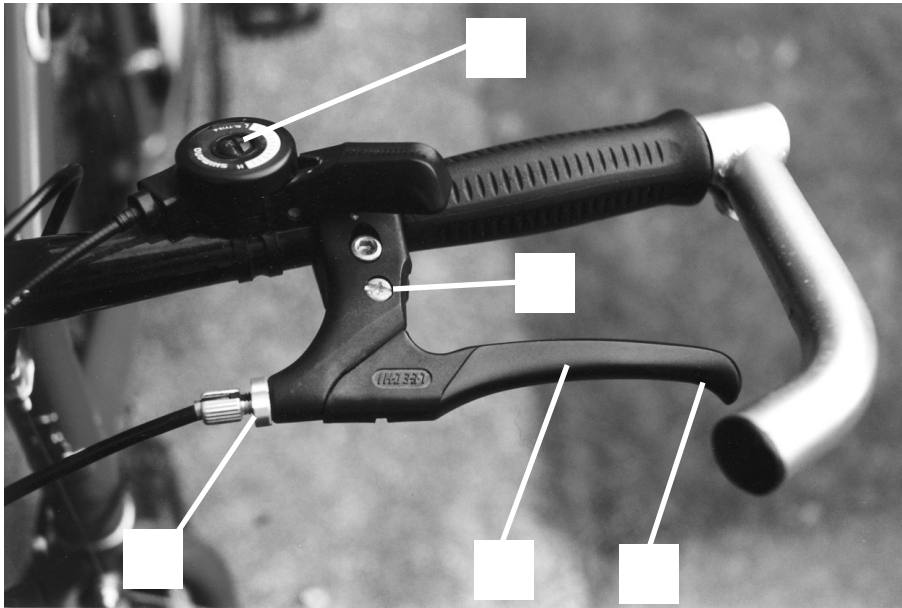


Fig. 9

- (i) Mark **F** for fulcrum in the box on Fig. 9 which is pointing to the fulcrum of the brake lever. [1]
- (ii) Mark **L** for lever in the position on the lever that will provide the maximum gain in force when the lever is operated. [1]
- (d) Two types of mountain bike brake are shown in Fig. 10.



centre pull brake



disc brake

Fig. 10

Explain why the disc brake is a more efficient braking system.

.....

.....

..... [2]

[Total: 12]

Section A Total [36]

Section B

Answer **all** questions

- 4** A test rig is required to test wear on fabric. Fig. 11 shows part of the rig.

The pressure pad can move backwards and forwards and slides into position in the T slots.

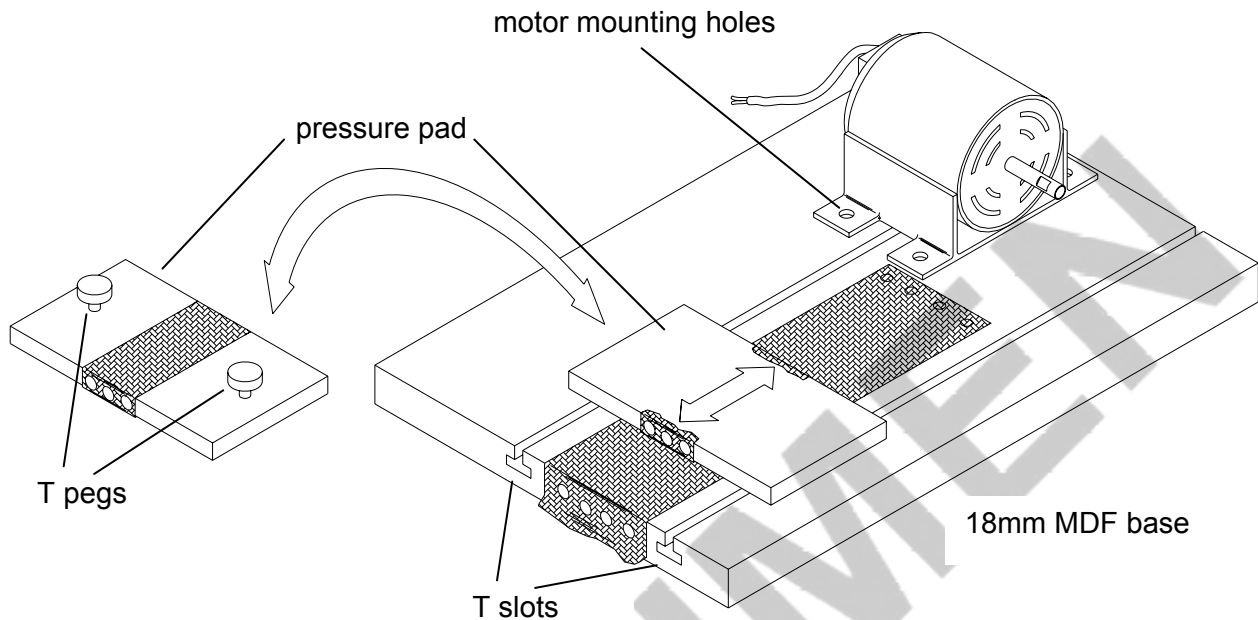


Fig. 11

- (a)** Use notes and sketches to show a method of securing the motor to the 18mm MDF base. The method used must ensure that the motor cannot vibrate loose.

[3]

- (b)** A mechanism is needed to move the pressure pad 25mm backwards and 25mm forwards across the fabric.

- (i)** State the name of a mechanism that will convert rotary motion to reciprocating motion.

..... **[1]**

- (ii) The motor shaft is Ø10 with a flat machined on the end of it.

Use notes and sketches to show a suitable mechanism to be attached to the motor that will provide a total horizontal movement of 50mm.

[5]

- (iii) Use sketches to show how your mechanism is attached to the motor.

[2]

- (c) Friction between the two pegs and the slots should be kept to a minimum.

Give the name of a suitable material for the two pegs that will reduce friction in the movement of the pressure pad.

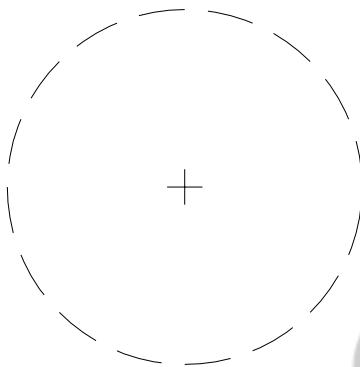
..... [1]

[Total: 12]

- 5 A student is designing a mechanical toy that will use a cam to make the outline of a bird rise and fall as a handle is rotated.

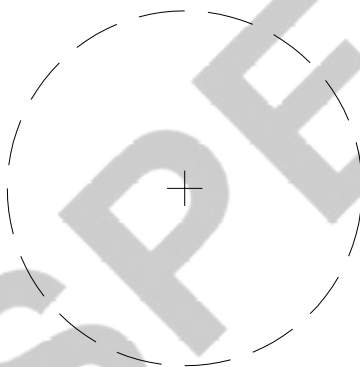
- (a) On the three outlines shown in Fig. 12 draw the following cam outlines:

- **one** smooth rise and fall with **continuous** movement;
- **one** smooth rise and **rapid** fall for each rotation;
- **two irregular** rise and fall movements.



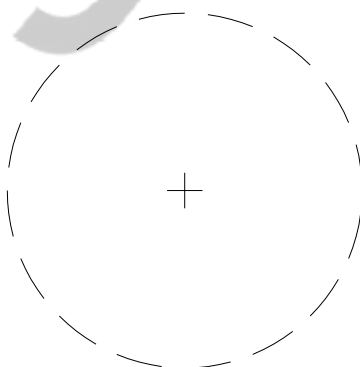
smooth rise and fall

[1]



smooth rise and rapid fall

[1]



two irregular rise and falls

[1]

Fig. 12

- (b) The outline of a framework that will hold the cam is shown in Fig. 13.

The top has been cut away to show the cam in position with a hole indicated for the cam follower.

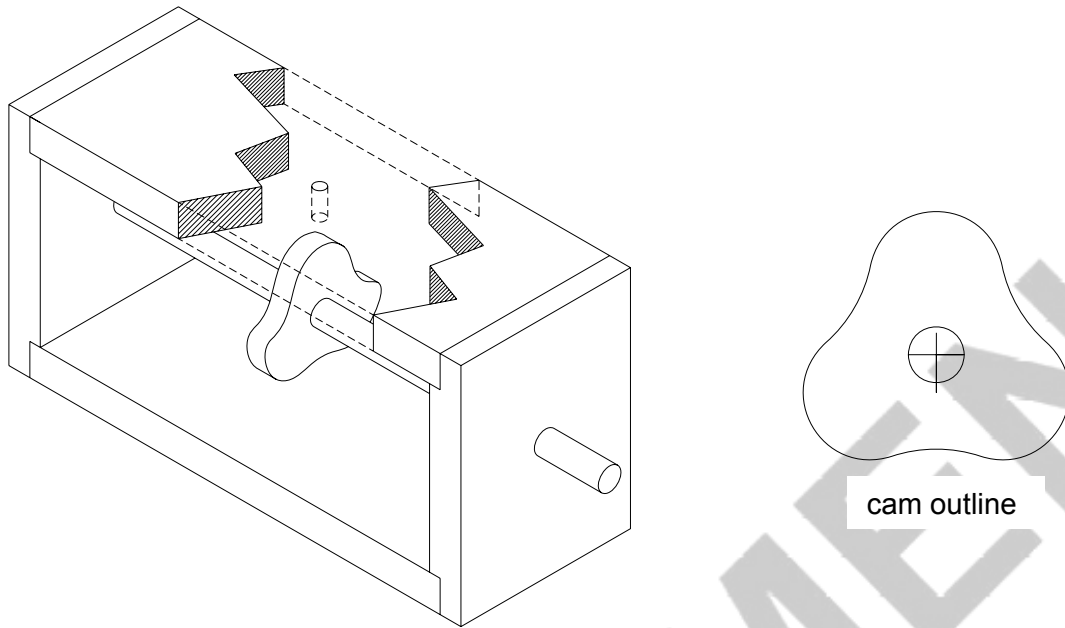


Fig. 13

- (i) Draw a roller follower on the cam outline in Fig. 13.
- (ii) Explain why the follower in Fig. 14 is unsuitable for this cam.

[2]

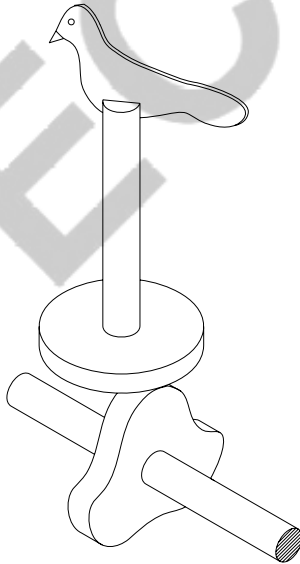


Fig. 14

.....

.....

..... [2]

(iii) Describe the result of using an offset follower as shown in Fig. 14.

.....
 [2]

(c) The camshaft is shown in Fig. 15 in position between the sides of the framework.

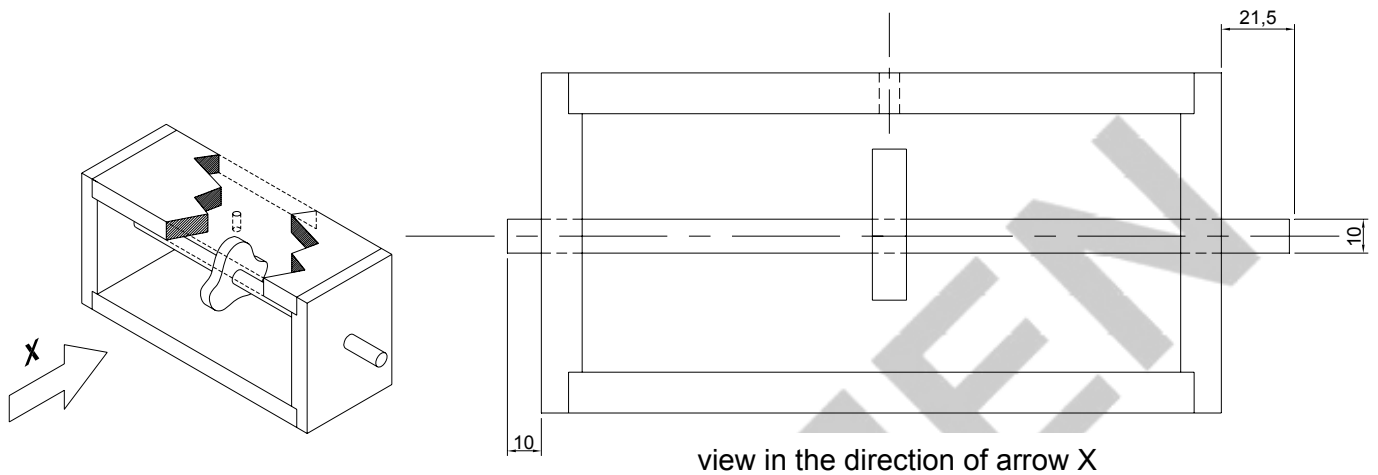


Fig. 15

Use notes and sketches to show a method of keeping the camshaft in position horizontally, preventing any side movement.

Include details of any additional components used.

[3]

[Total: 12]

Section **A** Total [24]

Paper Total [60]

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SPECIMEN

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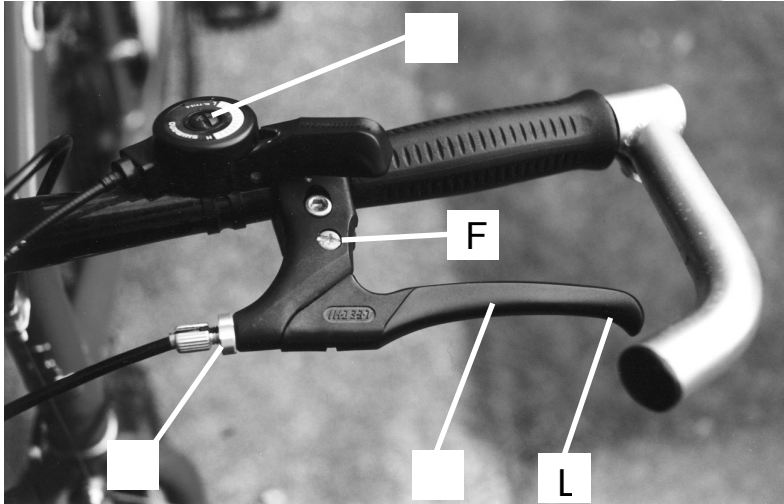
SPECIMEN

The maximum mark for this paper is 60.

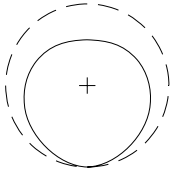
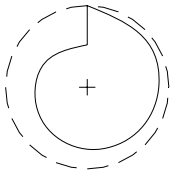
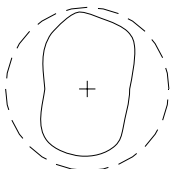
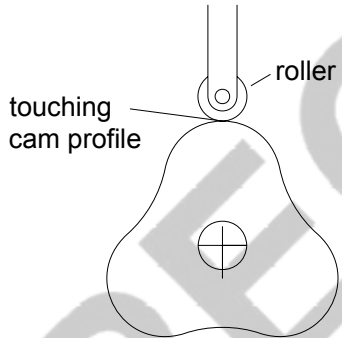
SPECIMEN

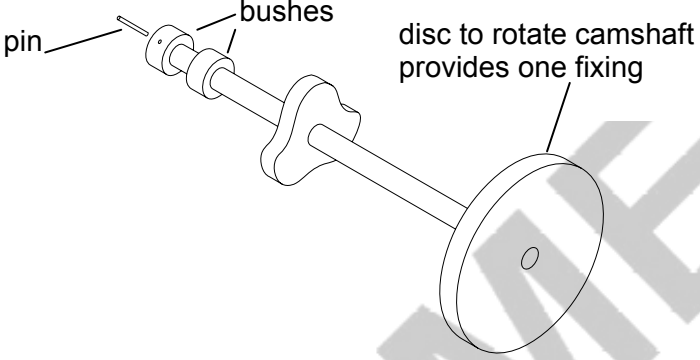
Section A		
Question Number	Answer	Max Mark
1(a)(i)	Bevel gear. Accept spur gear or pinion , 1 mark.	[1]
(ii)	driven / driver = $15 / 56 = 1 / 3.73 = 1 : 3.73$ 1 mark for substituting into formula, 1 mark for correct ratio.	[2]
(iii)	Speed of drill bit is $50 \times 3.73 = 186.6$ RPM. 1 mark for correct multiplication. 1 mark for 1 st stage, $50 \times$ answer from (ii); error carried forward.	[2]
(b)(i)	The brace uses a second class lever, accept second order lever.	[1]
(ii)	Increase in the crank throw will increase torque. Accept using a smaller diameter drill bit in the brace.	[1]
(c)(i)	Name of the mechanism is ratchet and pawl . Allow mark for either word correct.	[1]
(ii)	Spring loaded pawl will lift over slope of ratchet in one direction and lock in the other direction by dropping into the ratchet. 2 x 1. Brace mechanism shown has one pawl each side, one for each direction of rotation. Rotating collar will select pawl to be used or lock both in position. Allow marks for either generic ratchet and pawl description or for specific example shown.	[2]
(d)	Cramp A has finer pitch / more threads per inch or similar statement, or less distance moved for each rotation of handle, 1 mark. Handle of cramp A moves effort further from fulcrum, 1 mark. Allow 2 marks for clear explanation of one point.	[2]
	Total	[12]

Section A		
Question Number	Answer	Max Mark
2(a)(i)	Drive system A is a round belt; Drive system B is a toothed belt; Drive system C is a vee belt; Drive system D is a chain.	[1] [1] [1] [1]
(ii)	Benefit of system B could include: <ul style="list-style-type: none"> • less chance of slipping; • greater surface area in contact with pulley; • less chance of slipping from pulley. 1 mark for clear description of benefit.	[1]
(b)(i)	The machine shaft will be rotating faster than the motor shaft.	[1]
(ii)	Method that prevents rotational movement of pulley on shaft, 1 mark Method that prevents axial movement of pulley on shaft, 1 mark Removable method used, 1 mark.	[3]
(c)(i)	Reasons given could include: <ul style="list-style-type: none"> • Reduced friction; • Reduced surface area in contact; • Less maintenance / reduced frequency of lubrication; • Sealed from dust entry / lubrication leaking. 1 mark each for two suitable reasons or for clear explanation of one reason.	[2]
(ii)	The groove inside the plain bearing is for lubrication. Allow reference to oil or grease.	[1]
	Total	[12]
3(a)(i)	21 gears can be selected on the cycle.	[1]
(ii)	gear ratio = 49 / 16 , 1 mark = 3.06:1 , 1 mark. distance travelled = $3.06 \times 2075 = \mathbf{6354mm \pm 10mm}$, 1 mark. Allow error carried forward on distance travelled calculation.	[3]

Section A		
Question Number	Answer	Max Mark
(iii)	<p>Functions of the derailleur mechanism are:</p> <ul style="list-style-type: none"> to tension the chain; to move chain sideways onto different sprocket. <p>1 mark each, allow mark for understanding shown.</p>	[2]
(b)	<p>Properties of the wire are:</p> <p>strength in tension; resistance to bending; resistance to corrosion.</p> <p>1 mark for each correct property identified.</p>	[2]
(c)	 <p>Correct identification of fulcrum, 1 mark. Correct identification of lever position, 1 mark.</p>	[1] [1]
(d)	<p>Explanation could include the following points:</p> <ul style="list-style-type: none"> nearer to centre of wheel and will remain drier; nearer to centre of wheel and are less affected by mud; hydraulic system more positive action than cable – no stretching. perforations allow rain and mud to be quickly removed from the braking surface; <p>Explanation including two points 2 x 1 marks Award 2 marks for clear explanation of a single point.</p>	[2]
Total		[12]

Section A		
Question Number	Answer	Max Mark
4(a)	<p>Securing method may include the following features:</p> <ul style="list-style-type: none"> • Bolt / machine screw / set screw with nut to secure; • Spring washer, star washer or nyloc type nut to prevent fixing coming loose; • spit pin, wired nut or similar or note showing use of locking adhesive (loctite); • Use of rubber mounting pads to cut vibration. <p>2 x 1 marks for suitable components, 1 mark for workable method clearly shown.</p>	[3]
(b)(i)	Crankshaft or cam . 1 mark.	[1]
(ii)	<p>Sketches and notes should include:</p> <ul style="list-style-type: none"> • drawing or description of a crankshaft; • indication of a workable connecting method from crankpin to pressure pad; • dimensions to indicate a throw of 25mm, horizontal distance of 50mm; • details of both ends of connecting rod shown; • clear drawings / descriptions. 	[1] [1] [1] [1] [1]
(iii)	<p>Attachment method of mechanism to motor:</p> <p>boss on crank to allow grub screw or similar method, 1 mark</p> <p>Clear illustration of practical method, 1 mark.</p>	[2]
(c)	<p>Material for pegs should be a suitable bearing material such as nylon, allow acrylic. No mark for wood or manufactured board.</p>	[1]
	Total	[12]

Section A		
Question Number	Answer	Max Mark
5(a)	 <p>smooth rise and fall, 1 mark.</p>	[1]
	 <p>smooth rise and rapid fall, 1 mark.</p>	[1]
	 <p>two irregular rise and falls, 1 mark.</p>	[1]
(b)(i)	<p>Follower touching cam profile, 1 mark Roller clear to see or annotation clear, 1 mark.</p> 	[2]
(ii)	<p>The explanation should include the following points. The diameter of the cam follower will bridge the lowest point on each cam lobe, 1 mark. The cam follower will not travel the full rise and fall of the cam, 1 mark.</p>	[2]
(iii)	<p>An offset follower will rotate on its axis as well as rising and falling with the cam profile. Allow marks for understanding and or clear description of result. 1 mark for each movement of follower described.</p>	[2]

Section A		
Question Number	Answer	Max Mark
(c)	<p>The camshaft will require at least one end to be kept in position by bushes, washer and split pin or similar.</p> <p>Movement prevented in one direction, 1 mark.</p> <p>Movement prevented in both directions, 1 mark.</p> <p>Clear details of additional components, 1 mark.</p> <p>E.g.</p> 	[3]
	Total	[12]
Section A Total		[x]
Paper Total		[x]

Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
1(a)	4		1	5
1(b)	1		1	2
1(c)	3			3
1(d)	2			2
2(a)	4		1	5
2(b)	4			4
2(c)	3			3
3(a)	6			6
3(b)	2			2
3(c)	1		1	2
3(d)			2	2
4(a)	2		1	3
4(b)	8			8
4(c)	1			1
5(a)	3			3
5(b)	4		2	6
5(c)	3			3
Totals	51	0	9	60